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EVALUATION OF TELEMETRY RECORDS RECEIVED FROM EXPLORER VI AND PIONEER V

THE UNIVERSITY OF CHICAGO

LABORATORIES FOR APPLIED SCIENCES

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EVALUATION OF TELEMETRY RECORDS RECEIVED FROM EXPLORER VI AND PIONEER V

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FOREWORD

This is the fourth bi-monthly progress report under National Aeronautics and Space Administration Contract No. NASw-135, "Evaluation of Telemetry Records received from Explorer VI and Pioneer V," LAS Task E185, and covers the period 1 July to 31 August 1960.

The following personnel, both from the Laboratories for Applied Sciences and the Enrico Fermi Institute for Nuclear Studies, contributed to this program during the reporting period: auth: J. A. Simpson, Peter Meyer, Marstan Case, C. Y. Fan, and Christine Gloeckler. Oct. 1960 15p.

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Laboratories for Applied Sciences

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1. EXPERIMENTAL ARRANGEMENT

In order to determine the efficiency of the proportional counter telescope in counting bremsstrahlung, the backup payloads of Explorer VI and Pioneer V were taken to High Voltage Engineering Corporation on 13 June 1960.

High Voltage Engineering Corporation made two 2-Mev electron accelerators available for the experiment in which the low-energy limit of an external electron beam was found to be 0.25 Mev, determined by the absorption of the aluminum window (34 mg/cm^2). The beam was well focused at the window so that the x-ray background produced at the walls inside of the accelerator was reduced to not more than a few percent of the signal produced by the external beam.

The payload, which is of the shape of an oblate spheroid, with all the scientific apparatus except the scintillation counter of STL distributed on the "equatorial plane," was mounted in such a way that it could rotate about the spin axis (the axis perpendicular to the equatorial plane) and about a diameter in the equatorial plane. With a horizontal-beam accelerator, any part of the surface could be brought under direct bombardment of electrons by two rotations.

The shaded patches of Fig. 1 are a projectional view of the portions of half of the payload surface, selected for the bombardment of the electron beam, which form lattice points at approximately every 45°. For each bombardment, the ionization pulse rate of the ion chamber and the counting rates

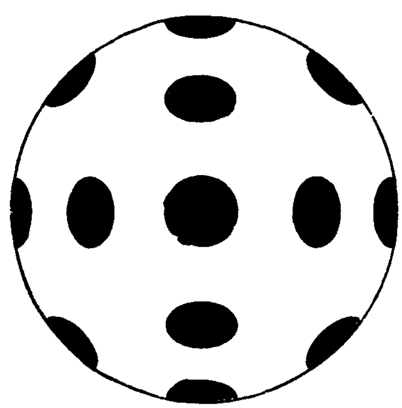

Figure 1. Projectional View of Half of Payload Surface

of the singles channel of the proportional counter telescope, the scintillation counters, and the GM counter were then separately monitored for intercomparison.

The way in which the experiment was performed differs in two respects from operation in space: (1) there were absorption and scattering by air inside of the payload, and (2) the electron beam was unidirectional. These are two of the factors which prevent an accurate comparison of the laboratory experiment with the measurement in space.

2. EXPERIMENT WITH ENERGY $\leq$ 500 KEV

The shell of Explorer VI is made of aluminum of 170 mg/cm^2. It is thick enough to stop electrons of energy $\leq$ 500 Kev. The response of a radiation detector to these electrons inside of the payload is thus totally due to the bremsstrahlung produced in the shell. The contribution from different parts of the shell for an equal flux of electrons will be approximately proportional to the inverse square of the distance to the detector from the irradiated area on the shell.

For experimental convenience, an aluminum absorber 2 in. in diameter and 0.032 in. thick was placed in close contact with the payload shell and the experiments were performed with the bremsstrahlung thus produced.

Figure 2 shows a plot of the counting rates of the central counter in the proportional counter telescope per 10^{-2} μa electron beam vs. the inverse squares of the distances from the absorber to the detector where the payload positions have been chosen to minimize the absorption in between them. The relation is approximately linear.

Figure 3 shows the counting rates per 10^{-2} μa beam current when the payload was bombarded with x-rays along the "equatorial region." The strongly peaked response in the neighborhood of the proportional counter telescope reflects the absorption by the distributed masses on the equatorial plane.

Because of the complex configuration of the payload, the response of the central counter in the counter telescope to the bombardment over the entire payload by a steady electron flux of energy E $<$ 500 Kev is done only for the following simplified division of the payload shell: (1) an equatorial zone

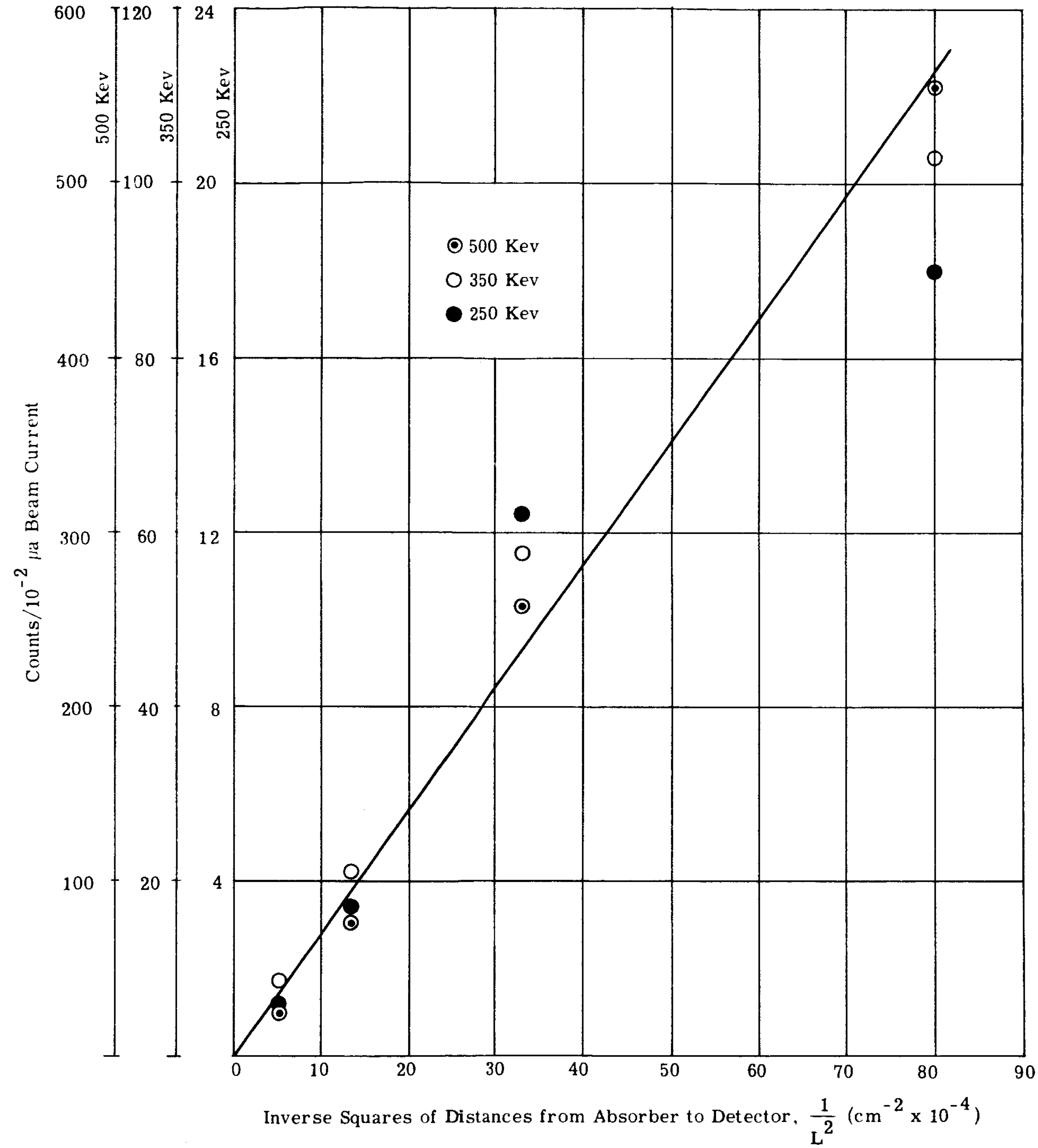

Figure 2. Counting Rates of Central Counter in Proportional Counter Telescope

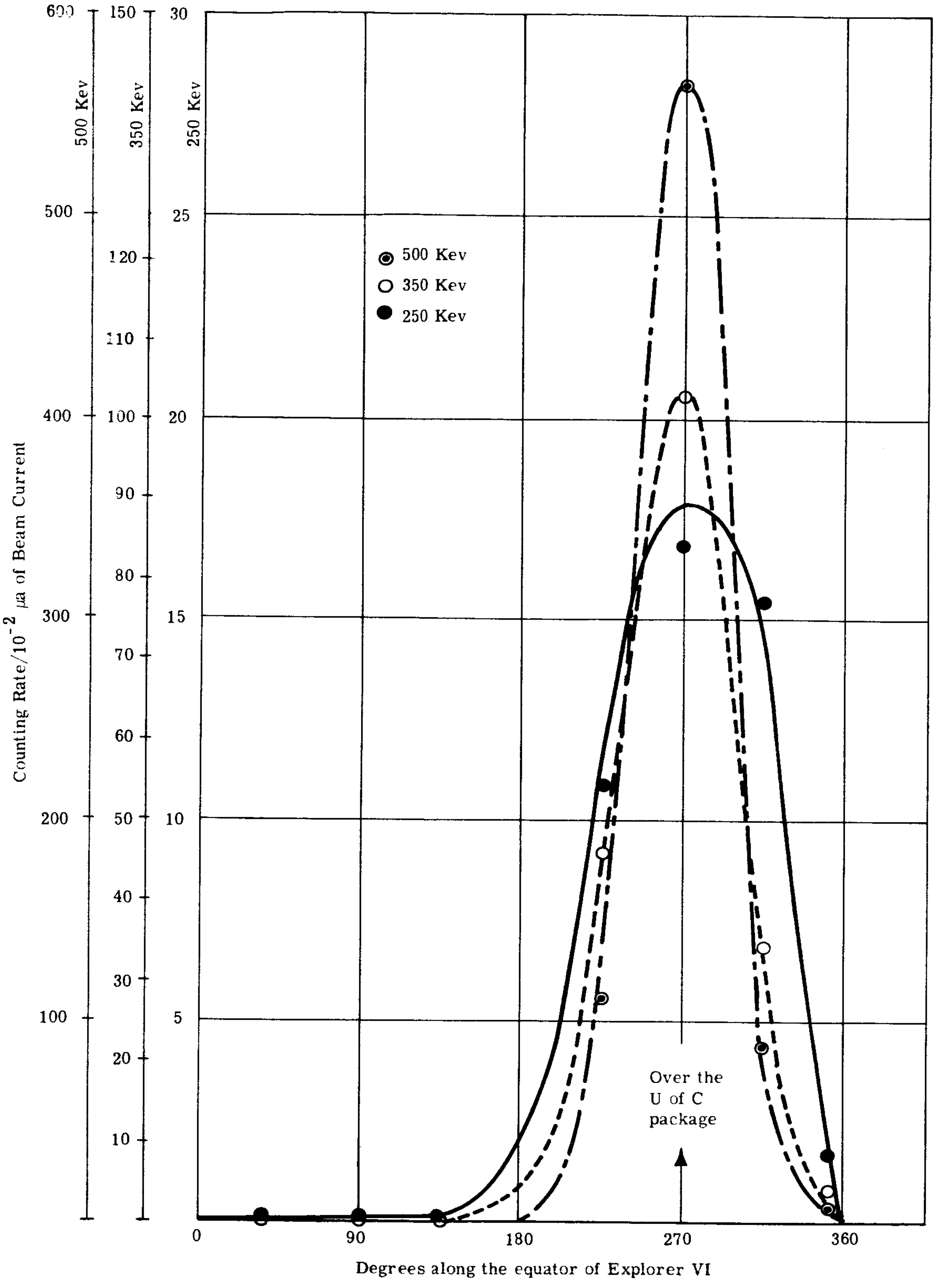

Figure 3. Counting Rates for Payload Bombarded with X-Rays along Equatorial Region

of height 16 cm for which the response curve can be represented by Fig. 3 and,(2) the remaining portion for which the response is inversely proportional to the square of the distance to the counter from an irradiated area on the shell. By using Fig. 2 and Fig. 3, the response can readily be calculated. The result is given in the following table:

Table 1

Counting Rate / 10^{-2} μa/ cm^2

Energy (Kev)	250	350	500
Counting Rate/ 10^{-2} μa/ cm^2 over the whole payload	5.3×10^4	26×10^4	128×10^4

3. EXPERIMENTS WITH ENERGY $\geq$ 500 KEV

One of the important differences between the present experiment and what actually happened in the radiation belts is that in the radiation belts the electron flux was nearly isotropic while in the present experiment the electron beam is unidirectional. For electrons of energy $\leq$ 500 Kev this difference, as we have already seen, is not significant. For electrons of energy > 500 Kev, on the other hand, the response of a detector to a unidirectional beam will be expected to be significantly different from that to an isotropic flux since electrons can then penetrate through the shell of the payload and the energy required for the penetration depends upon the angle between the momentum vector of the electrons and the normal to the payload surface.

Figure 4 shows a plot of the energy dissipation in the payload shell by one 1-Mev electrons at various angles of bombardment θ. When $\theta \geq 64^{\circ}40'$, the electron will be absorbed in the shell. It can then be shown that for an isotropic flux about 70% of the energy of 1-Mev electrons is converted into x-rays in the payload shell while for a vertically incident electron beam, only 30% of the energy is dissipated.

The surface density of the payload in the equatorial zone (16 cm high) is appreciably higher than the other portions since: (1) only the equatorial zone is lined with honeycomb material 150 mg/ cm^2 and (2) there were scientific equipments attached on many portions of the zone. The average surface density was approximately 400 mg/ cm^2. Consequently, the counts of the

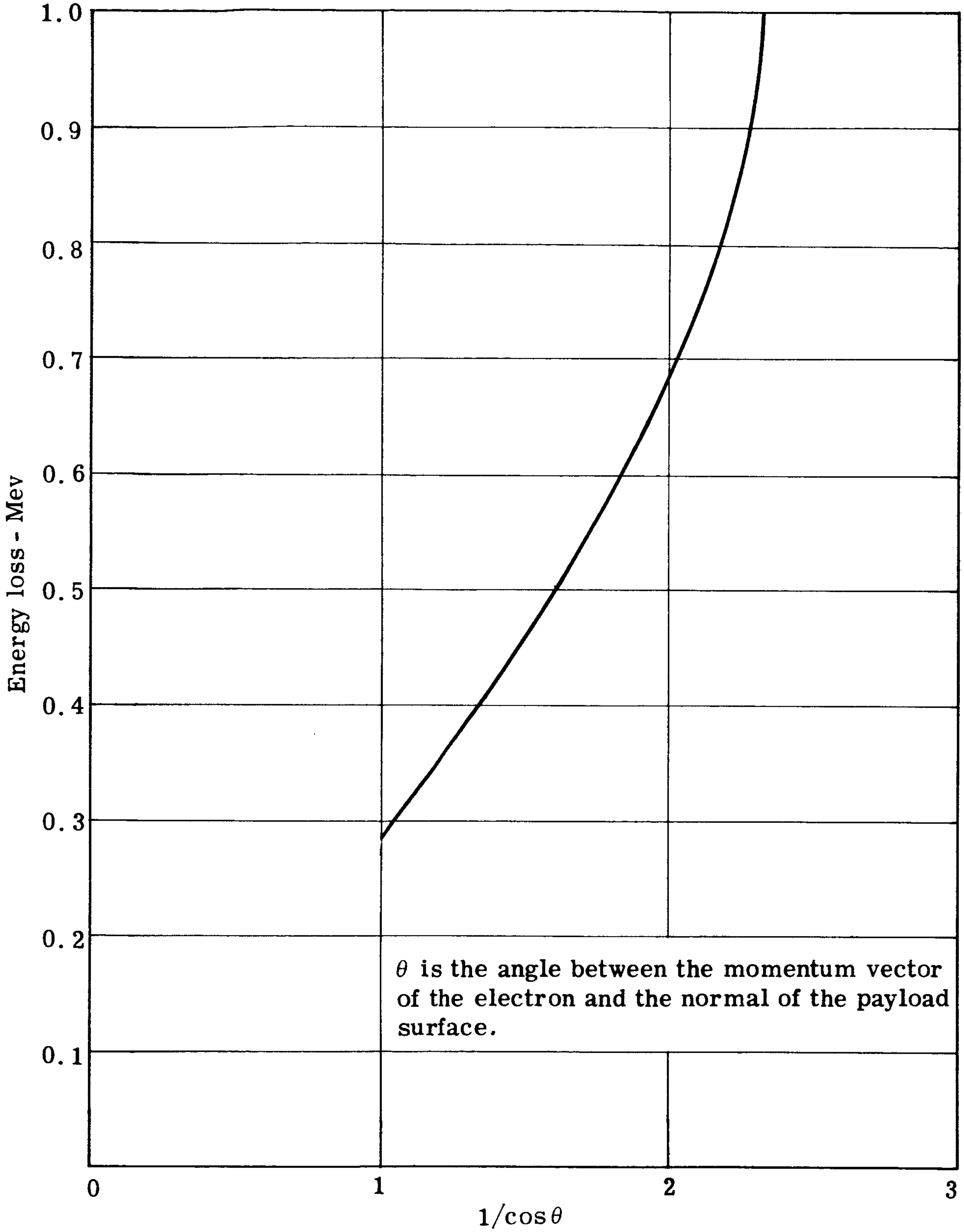

Figure 4. Energy Loss of One 1-Mev Electron vs. $1/\cos\theta$

proportional counter produced by the bombardment of electrons of $E \geq 1$ Mev will again be due to bremsstrahlung produced in the payload surface and thus the angular distribution of the electrons no longer enters into the picture.

Figure 5 shows the counting rate/10^{-2} μa beam current produced by 1-Mev electrons bombarding along the equatorial zone. The peak value produced by 1-Mev electrons and the peak value produced by 750-Kev electrons agree quite well with the extrapolation of the straight line determined by the peak values produced by 250, 350, and 500-Kev electrons respectively, as shown in Fig. 6. The apparent deviation of the peak value produced by 1.9-Mev electrons reflects the relatively high penetration of the electrons.

The surface density of the rest of the payload was only 170 mg/cm^2, and thus the angular distribution of the electron flux becomes important. However, the case in which we are interested is an isotropic distribution and for this distribution with an electron energy ≤ 1 Mev, more than 70% of the energy is converted into x-rays in the shell. Furthermore, at least half of the counts of the proportional counter are contributed by electrons bombarding the equatorial zone of the satellite over the University of Chicago package as it is in this zone. Therefore, for the first order approximation, one can assume that all the energy of electrons of energy ≤ 1 Mev was converted into x-rays in the payload shell and thus the counting rate/10^{-2} μa/cm^2 over the whole payload can be calculated easily. The results are plotted in Fig. 7. Within the experimental accuracy, it can be expressed in the following equation:

$$n = 3.5 \times 10^7 E^{4.7} \quad ,$$

when E is in units of Mev. For comparison, the same quantity for the STL scintillation counter is plotted as a dotted line.

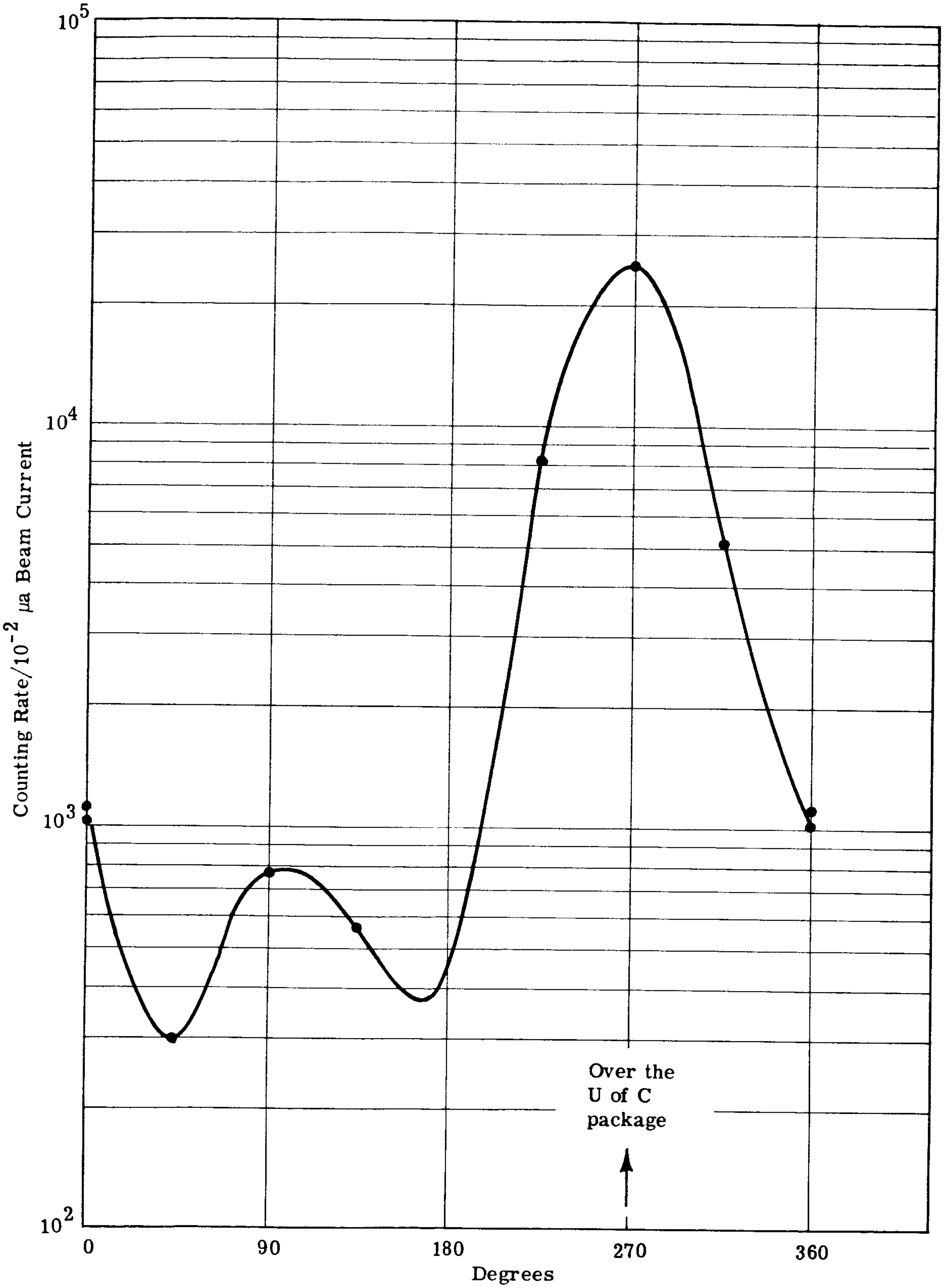

Figure 5. 1 Mev Electrons along the Equatorial Region

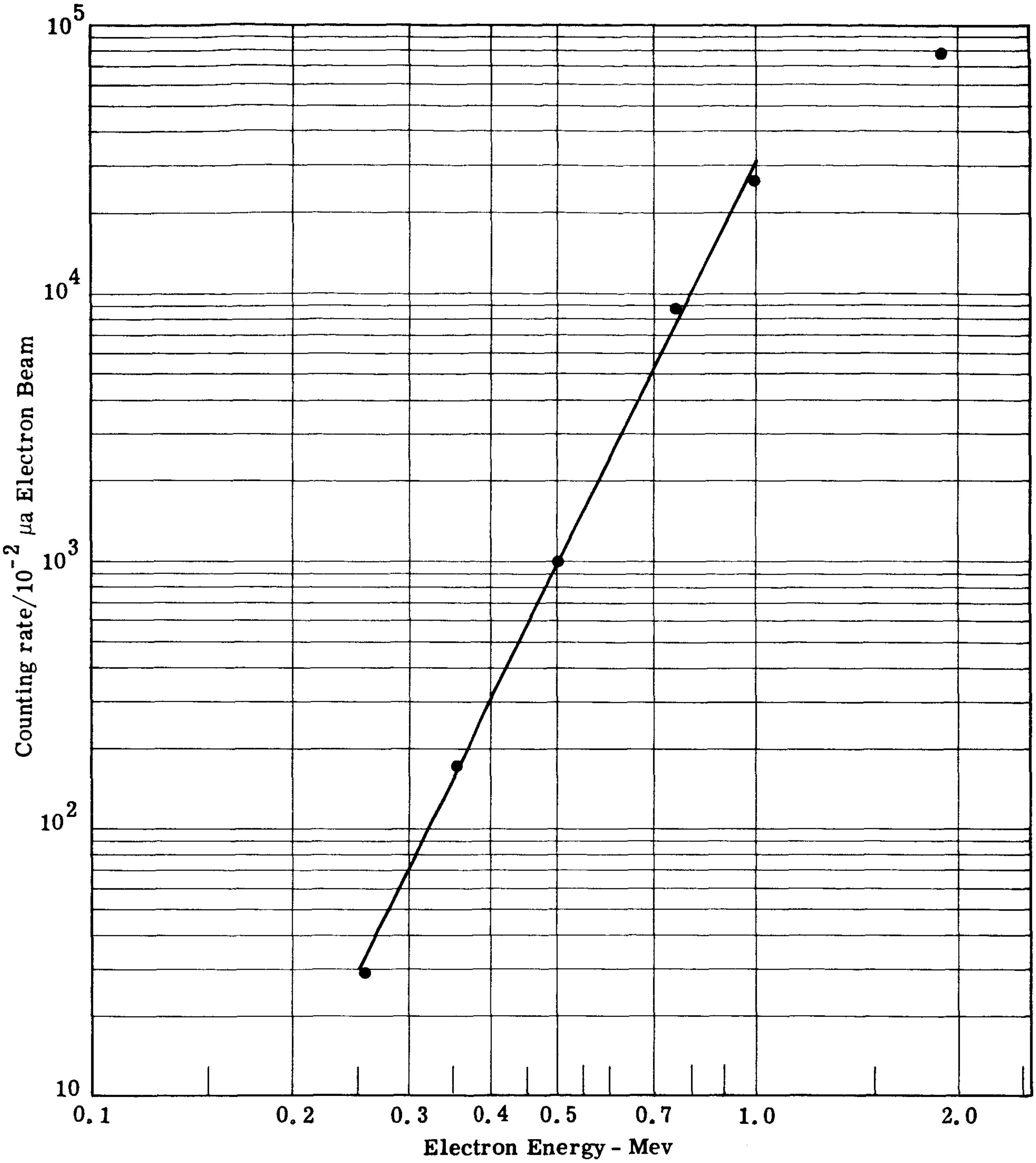

Figure 6. **Maximum Counting Rates Produced by Electrons of Various Energies Bombarding along the Equatorial Zone**

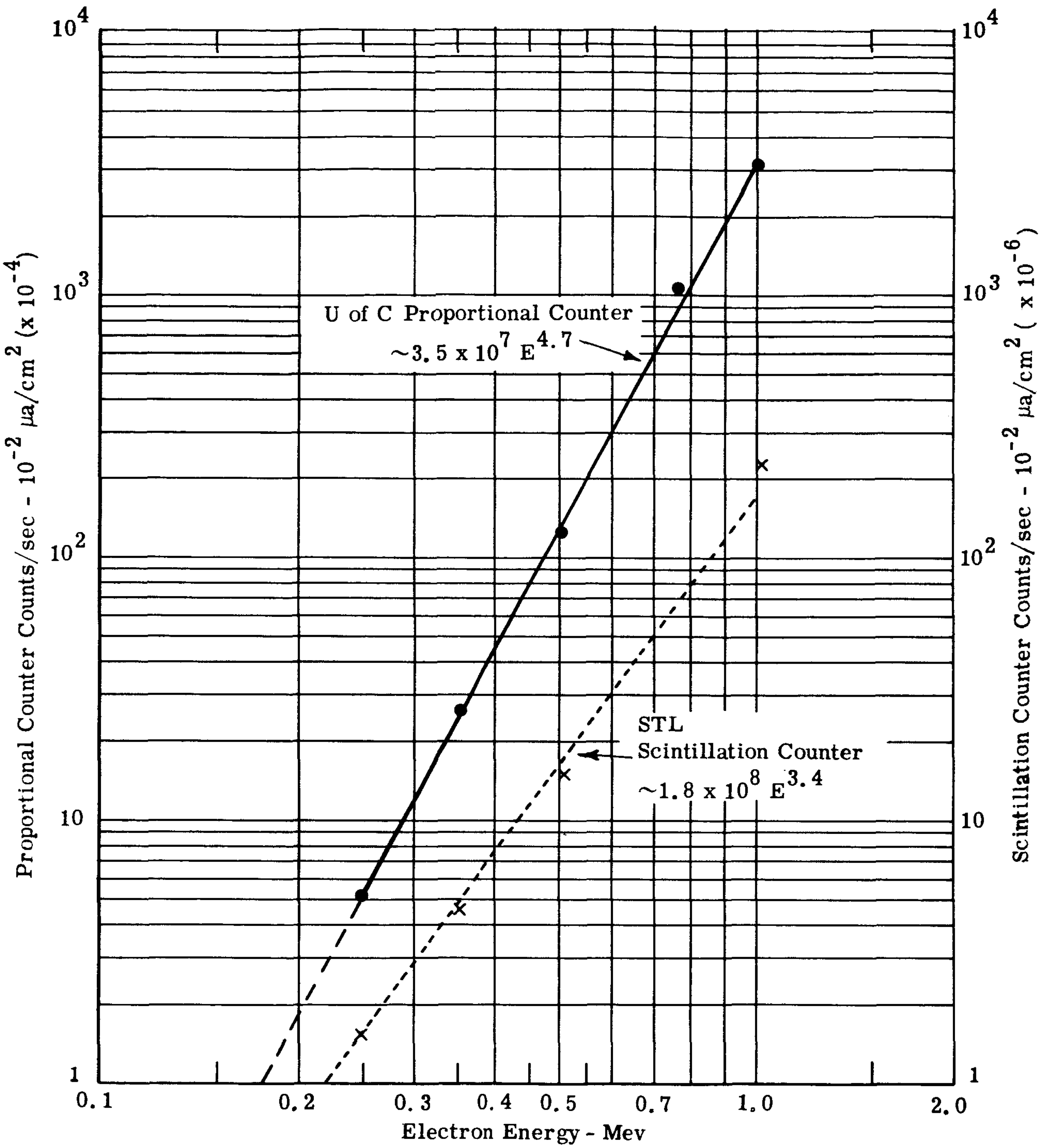

Figure 7. Counting Rate of Center Counter of Proportional Counter Telescope as Function of Electron Flux Bombarding Isotropically over Payload